PHOTOMETRIC MEASUREMENTS OF DAYLIGHT ILLUMINATION ON A HORIZONTAL SURFACE AT MOUNT WEATHER, VA.

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Measurements of the daylight illumination on a horizontal surface freely exposed to the sky, including that part of it occupied by the sun, or to the sky alone with the sun artificially eclipsed, were made at Mount Weather from September 17, 1913, to September 15, 1914. They were made at intervals throughout the day on most clear days, and also on cloudy days when the cloud layer was of sufficiently uniform thickness to permit of satisfactory light intensity measurements. Ordinarily in cloudy weather, and especially during the summer months, the light intensity varies so rapidly that measurements have little significance. The pressure of other work prevented photometric measurements during March and April, 1914.

The measurements were made with a Sharp-Millar photometer (1), and the character of the instrumental exposure is shown in this REVIEW for August, 1914, figures 3 and 4, opposite page 477. It was necessary to provide a milk glass screen, in addition to the two neutral glass screens L and D furnished with the instrument, to reduce daylight illumination to an intensity that could be measured by the photometer. This screen had a transmission coefficient of 1/288; and the two neutral glass screens had coefficients of 0.138 and 0.041, respectively, when used in connection with the milk glass screen.

It was also found necessary to provide two blue glass screens, VA and VIA, to reduce the light of the comparison lamp to the color of daylight, and to the color of the light from the sky alone, respectively. The transmission coefficient of VA was 0.235, and that of VIA was 0.112.

With the exception of a few measurements of twilight illumination, the milk glass screen was used in all light intensity measurements, and the neutral glass screen L in nearly all. It was sometimes omitted on clear days when the sun was near the horizon, and also on days with dense clouds. In summer near midday with a clear sky it was sometimes necessary to replace it with the neutral glass screen D.

The blue glass screen VA was also used in nearly all light intensity measurements. The color of the light from the comparison lamp transmitted by this screen matched very closely the color of the total light from the sky and sun, and also the light from an overcast sky. The light from the clear sky alone was decidedly blue in comparison with it, and in a few measurements of sky-light illumination blue glass screen No. VIA was employed. Experience demonstrated, however, that the increased accuracy of measurements obtained when using VIA, arising from a better color match, was more than offset by the disadvantage arising from the decrease in the intensity of the light from the comparison lamp transmitted by this screen.

The three following combinations of screens, and the accompanying factors to reduce scale readings on the photometer to foot-candles of illumination, will, therefore, apply to most of the photometric measurements made at Mount Weather.

(1) Milk glass, and blue glass VA,
Factor$=288\times0.235,\ =67.68.$

(2) Milk glass, blue glass VA, and neutral glass L,

$$\text{Factor}=\frac{288\times0.235}{0.138}=490.4.$$

(3) Milk glass, blue glass VA, and neutral glass D,

$$\text{Factor}=\frac{288\times0.235}{0.041}=1651.$$

The United States Bureau of Standards furnished the milk glass screen and the two blue glass screens, and determined the transmission coefficients of all the screens. It also standardized the comparison lamp; but in order to eliminate the personal equation of the observer as far as possible the author made the final comparisons between this lamp and a standard lamp. The original comparisons consisted in determining the electric current required in the lamp circuit to give scale readings on the photometer expressed in foot-candles of illumination, with all the screens removed. In recomparisons made on November 8, 1913, January 3, 1914, June 16, 1914, and October 8, 1914, the current was adjusted to the amperage determined on the original test, and the illumination of the standard lamp was read by means of the photometer in the usual way. No change of consequence was detected in the comparison lamp until October 8, 1914, when its readings were about 5 per cent low. A graded correction of from 1 to 5 per cent has therefore been applied to the readings obtained after June 16, 1914.

The Bureau of Standards certificate states that the transmission coefficients of the various glass screens are correct to within 1 to 3 per cent. Most of the photometer readings were made by the writer. Each illumination measurement is the mean of three independent settings of the photometer, and the extreme difference in these individual readings is rarely more than 5 per cent. Some readings were made by Mr. I. F. Hand, and there is no evidence that his readings differ materially from my own. It is probable that the readings given are correct to within ±5 per cent.

TABLE 1.—*Photometric readings at Mount Weather, Va., on June 30, 1914.*

Sun's hour angle.	Sun's altitude.	Exposure.	Screens.	Photometric readings. 1	2	3	Mean.	Illumination.	Clouds.
A. M.									
h. m.	*Deg.*							*Foot candles.*	
5 55	14.3	Sky	VA+L	1.50	1.49	1.48	1.49	729	Few ci.
5 52	15.8	Total	VA+L	7.25	7.22	7.20	7.22	3,542	Few ci.
4 45	28.5	Sky	VA+L	1.58	1.61	1.60	1.60	783	Few ci.
4 11	35.1	Total	VA+L	10.2	10.2	10.2	10.2	4,979	Few ci.
2 58	49.1	Sky	VA+L	1.79	1.76	1.78	1.78	871	Few ci.
2 55	59.8	Total	VA+L	16.5	15.5	16.0	16.0	7,827	Few ci.
1 42	62.2	Sky	VA+L	1.88	1.87	1.87	1.87	915	Few ci.
1 38	62.8	Total	VA+D	5.80	5.75	5.85	5.80	9,576	Few ci.
0 41	71.9	Sky	VA+L	2.00	2.03	2.04	2.02	988	Few ci.
0 37	72.3	Total	VA+D	5.95	5.91	6.08	5.98	9,873	Few ci.
P. M.									
0 49	71.1	Sky	VA+L	2.15	2.12	2.20	2.16	1,058	1 cu.
0 52	70.7	Total	VA+D	5.80	6.00	5.80	5.87	9,691	1 cu.
2 48	51.2	Sky	VA+L	2.30	2.31	2.30	2.30	1,126	1 cu.
2 51	50.5	Total	VA+L	15.9	15.6	15.8	15.8	7,728	1 cu.
4 48	28.0	Sky	VA+L	1.94	1.90	1.92	1.92	939	2 cu.
4 51	27.4	Total	VA+L	7.20	7.19	7.30	7.23	3,547	2 cu.

Table 1 presents the readings recorded on June 30, 1914. For reasons given above these were increased by 1 per cent before they were included in the tabulation that follows. The exposure to the sky alone was effected by artificially eclipsing the sun by means of the screen shown at D in figure 4, opposite page 477 of the current volume of this REVIEW.

The data of Table 2 have been obtained by plotting observations similar to those in Table 1, taking illumination measurements as ordinates and the sun's hour angle from the meridian as abscissas, and drawing a smooth curve through the measurements of *total* illumination. A curve drawn through similar plottings of measurements of *sky* illumination enables us to obtain the data in Table 3.

These latter curves enable us to interpolate sky-illumination values for the times at which measurements of the total illumination were obtained. The difference gives the solar illumination on a horizontal surface. Dividing this difference by the sine of the sun's altitude at the time of the observation gives the solar illumination on a surface normal to the direction of the incident solar rays. The logarithms of these latter values were plotted against the air masses, or approximately the secant of the sun's zenith distance at the time of observation; and the resulting curves, which under favorable sky conditions approximate straight lines, gave the data presented by Table 4.

A study of Tables 2 and 4 shows that from September to February, inclusive, at all hours of the day, solar illumination at normal incidence generally exceeds the total illumination on a horizontal surface; but that from May to August, inclusive, the illumination on a horizontal surface is in excess for from four to eight hours in the middle of the day. In general, the hazier the sky the greater and the longer continued is the midday excess of the total horizontal illumination over the direct solar illumination.

TABLE 2.—*Photometric measurements of the illumination of a horizontal surface by sun and sky light, with no clouds present, at Mount Weather, Va.*

[Foot-candles.]

Date.	Hour angle of the sun from the meridian.											
	6.0	5.0	4.0	3.0	2.0	1.0	0.0	1.0	2.0	3.0	4.0	5.0
1913. Sept. 23..		1,300	3,040	4,570	6,570	7,350	7,500	7,270	6,400	4,720	2,940	
24..			2,400	4,140	5,880	6,640	6,810	6,680	6,120	4,330	2,860	
Oct. 4..		1,010	2,820	4,510	6,190	7,020	7,290	7,070				
14..			2,030	4,030	6,110	6,980	6,950	6,680	5,630	4,040	2,120	500
16..			2,080	3,770	5,380	6,390	6,700	6,210	5,090	3,660	1,920	
Nov. 4..							4,670	4,340	3,430	2,160	910	
5..			1,330	3,080	4,370	5,380	5,630	5,280	4,450	3,150	1,500	
6..			1,370	2,970	4,560	5,440	5,640	5,360	4,430	3,170	1,450	
7..				2,820	4,350	4,840	5,200					
12..			1,350	2,210	3,750	4,920	5,250					
21..					3,350	4,200	4,590	4,300				
Dec. 5..			660	1,900	3,090	3,950	4,300					
9..				1,940	3,270	4,030	4,180	3,960	3,140			
12..			650	1,930	3,150	3,990	4,320					
18..			490	1,460	2,390	3,430						
1914. Jan. 6..								3,890	3,220	1,980	680	
23..				1,460	2,390	3,210	3,610	3,500				
26..						3,880	4,460	4,430	3,580	2,[illegible]00	960	
29..				2,330	3,570	4,550	4,720	4,420				
Feb. 2..							5,210	4,810	4,070	2,810	1,210	
9..							5,280	4,980	4,050	2,680	1,370	
21..					4,720	6,330	6,680	6,590	6,010			
24..						6,130	6,260	6,030	5,280	3,860	1,960	
May 1..	770	2,460	4,280	6,150								
15..		2,570	4,150	6,340	7,770	8,280	8,390					
16..			4,610	5,760	6,850	7,910						
18..			4,330	6,300	7,640	8,200	8,230	7,820	7,100	6,170	4,500	2,890
19..			4,210	6,220	7,790	8,760						
20..		2,000	3,540	5,420	7,360	7,590	7,380	6,690	5,920	5,110	3,200	
21..									7,150	5,890	4,160	
26..				5,920	6,200	6,430	6,560	6,530	6,300			
June 2..			5,080	7,040	8,270	9,020	9,320					
3..						8,620						
10..			4,960	6,540	7,990	8,880	9,400					
12..				6,740	8,100							
24..		3,150	4,810	6,770	8,190	9,270						
26..				5,900	8,050							
30..		3,540	5,350	6,830	9,090	9,900	10,000	9,720	9,060	7,520	5,500	3,210
July 22..	1,350	3,250	5,410	6,720	8,470	9,510						
29..		3,350	5,500	7,610								
Aug. 7..		2,220	3,870	5,660	7,150	8,320						
Sept. 10..				5,630	6,910	7,620	8,390					
15..									7,180	5,850	3,680	2,240

TABLE 3.—*Photometric measurements of the illumination of a horizontal surface by sky light alone, with no clouds present, at Mount Weather, Va.*

[Foot-candles.]

Date.	Hour angle of the sun from the meridian.											
	6.0	5.0	4.0	3.0	2.0	1.0	0.0	1.0	2.0	3.0	4.0	5.0
1913. Sept. 23..			785	904	951	988	1,139	1,191	1,173	1,112		
24..				1,084	1,388	1,516	1,554	1,534	1,465	1,309	990	
Oct. 4..		577	965	1,126	1,180	1,200	1,200					
14..			759	908	1,014	1,093	1,110	1,088	1,017	908	747	
16..			788	970	1,109	1,193	1,214	1,207	1,142	1,012	823	
Nov. 4..							1,514	1,476	1,340	1,093	686	
5..			608	837	973	1,033	1,050	1,036	973	834	593	
6..			684	778	855	903	920	890	840	740	570	
7..				756	944	1,266	1,452					
12..			670	848	985	1,030	1,030					
21..					1,178	1,276	1,305	1,200				
Dec. 5..			435	645	753	938	1,100					
9..				739	855	928	940	900	808			
12..			410	653	778	834	852					
18..			372	815	1,075	1,216						
1914. Jan. 6..								1,070	924	748	450	
23..				1,344	1,745	1,924	1,950	1,800				
26..							1,277	1,250	1,144	905	580	
29..				780	955	994	1,072	1,080				
Feb. 2..								760	760	690	508	
9..								900	878	772	540	
21..					1,054	1,060	1,060					
24..								1,220	1,220	1,118	706	
May 1..	642	1,400	1,800	2,158								
15..				2,318	2,568	2,728	2,868					
16..			1,672	1,938	2,092	2,165	2,178					
18..			1,475	1,740	1,875	1,935	1,934	1,885	1,784	1,612	1,370	1,050
19..			1,875	2,028	2,470	2,933						
20..		1,470	2,016	2,355	2,600	2,746	2,818	2,800	2,615	2,100	1,516	
21..									2,137	1,985	1,720	
26..					2,800	2,600	2,500	2,600	2,770			
June 2..			980	1,425	1,750	1,480						
3..						1,980	1,880					
10..			1,185	1,210	1,360	1,720	2,000					
12..				1,190	1,220							
24..		830	960	1,080	1,200	1,330						
26..				1,440	1,580							
30..		750	810	870	920	980	1,040	1,050	1,110	1,130	1,050	920
July 22..	580	880	1,070	1,210	1,290	1,360						
29..		750	870	970								
Aug. 7..		1,390	1,900	2,160	2,410	2,750						
Sept. 10..				780	790	800	820					
15..									890	800	710	640

Comparison of Tables 2 and 3 shows marked variations in the ratio of sky-light illumination to the total illumination on a horizontal surface. In general, the ratio decreases as the sun approaches the zenith. In October and November, 1913, the sky illumination was about half the total when the sun was 10° to 11° above the horizon. On January 23, 1914, a very hazy day, it was more than half the total at noon, with the sun over 30° above the horizon. At noon on June 30, 1914, a very clear day, it was only one-tenth the total, while throughout May, 1914, an unusually hazy month, the noon ratio was about one-third.

If we divide the light intensities of Table 4 by the radiation intensity at normal incidence for the same days (2), we obtain the illuminating value of a calorie of solar heat energy for these days. This value is greater on clear days than on hazy days, and decreases in value with increased zenith distance of the sun. Thus, with the sun at zenith distance 48.3°, the average illuminating value of a calorie of solar radiation is 5,600 foot-candles; for solar zenith distance 66.5° it is 5,100 foot-candles, while for solar zenith distance 73.5° it is 4,600 foot-candles.

Similarly, comparisons of photometric measurements made on days when the sky was completely overcast with synchronous records by the Callendar pyrheliometer of the heat energy received through the clouds, give 6,250 foot-candles per calorie as the average illuminating value of this diffuse radiation. Comparisons of the photometric readings of Table 3 with Callendar pyrheliometric records of the diffuse heat received from the clear sky, with the sun artificially eclipsed as explained above, give 8,900 foot-candles per calorie. These two latter values are subject to whatever error there may be in the reduction of the Callendar records to heat units (3).

The above comparisons indicate that radiation from an overcast sky is slightly richer in light rays, and radiation from a clear sky is markedly richer, than is direct solar radiation. They also show that the latter decreases in richness as the sun approaches the horizon, and also with a hazy sky. This is in accord with the researches by the Smithsonian Institution on atmospheric transmission of solar radiation of different wave-lengths (4).

TABLE 4.—*Solar illumination on a surface normal to the direction of the incident solar rays.*

[Foot candles.]

Date.	Zenith distance of the sun (degrees).									
	25.0	48.3	60.0	66.5	70.7	73.6	75.7	77.4	78.7	79.8
	Air mass.									
	1.1	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
1913.										
Sept. 23 a.		7,840	6,850	5,980						
24 a.		6,360	5,730	5,160						
Oct. 4 a.		8,040	6,850	6,020	5,380	4,890	4,470	4,110	3,780	3.480
14 a.		8,710	7,360	6,240	5,270	4,470				
16 a.		8,040	6,740	5,660	4,490	3,570				
Nov. 4 a.		6,040	4,630	3,760	2,700	2,100	1,680	1,340		
5 a.		8,520	7,620	6,690	5.870	5,160	4,520			
5 p.			7,570	6,870	6,220	5,640	5,100	4,520	4,190	3,810
6 a.			7,770	6,760	5,890	5,120	4,460	3.880		
6 p.			7,800	7,100	6,320	5,850	5,310	4,830	4,390	3,980
7 a.			7,320	6,500	5,760					
12 a.			7,140	5,930	5,100	4,570	4.300	3,940		
21 a.			5,970	4,830						
Dec. 5 a.			7,250	6,370	5,750	4,920	4,330			
9 a.			7,420	6,370	5,510	4,920	4,390			
9 p.				6,460						
12 a.			6,650	6,120	5,630	5,180	4,760	4,400		
18 a.				3,910	3,250	2,870	2,570	2,320	2,100	1,920
1914.										
Jan. 6 p.				6,050	5,520	4,840	4,190	3,770	3,510	3,290
23 a.			3,200	1,610	762					
26 a.			6,270	4,960	4,270	3,820	3,450	3.140		
29 a.			6,300	5,460	4,980	4,590				
Feb. 2 p.			7,280	6,470	5,940	5,490	5.040	4,610	4,210	3,850
9 p.		8,150	6,460	5,440	4,900	4,560	4,300	4,050		
24 p.		7,810	6,460	5,630	5,030	4,560				
May 1 a.		5,640	4,960	4,390	3,880	3,450				
15 a.	6,940	5,160								
16 a.	6,140	5,520	4,770							
18 a.	6,840	5,520								
18 p.		6,050	4,810	3,830						
19 a.	6,180	5,180								
20 a.	5,380	3,480								
20 p.		3,290								
21 p.	6,030	5,020								
26 a.	6,020									
June 2 a.		7,210								
3 a.	6,940									
10 a.	7,710	5,260								
12 a.	8,180	7,000								
24 a.	8,350	6,900	5,800	5,130						
30 a.	9,700	8,250								
30 p.	9,180	8,130								
July 22 a.	8,870	7,710	6,530	5,610	4,860	4,260	3,790			
29 a.		8,560	6,810							
Aug. 7 a.	6,230	4,230	3,340	2,630	2,100					
Sept. 10 a.		8,100								
15 p.		8,630	7,710	6,830	5,970	5,160				

TABLE 5.—*Photometric measurements of daylight and twilight illumination on a horizontal surface, at Mount Weather, Va.*

Nov. 4, 1913.[1]				Nov. 5, 1913.[2]				Nov. 6, 1913.[3]			
Sun's		Illumination.		Sun's		Illumination.		Sun's		Illumination.	
Hour angle.	Altitude.	Total.	Sky.	Hour angle.	Altitude.	Total.	Sky.	Hour angle.	Altitude.	Total.	Sky.
H. m.	*Deg.*	*Foot-candles.*		*H. m.*	*Deg.*	*Foot-candles.*		*H. m.*	*Deg.*	*Foot-candles.*	
0 03	35.7	4,670		0 07	35.3	5,730		0 05	35.0	5,580	
0 01	35.7		1,520	0 04	35.4		1,000	0 02	35.0		932
1 24	32.2		1,460	1 04	33.4		994	1 05	32.9		893
1 27	32.0	3,980		1 08	33.1	5,170		1 10	32.6	5,260	
1 41	30.8	3,620		2 06	28.0		963	2 05	22.8		814
1 45	30.4		1,345	2 10	27.6	4,370		2 08	22.4	4,210	
3 09	20.0		1,040	3 09	19.9	2,952		3 05	20.2	2,960	
3 13	19.4	1,870		3 12	19.4		814	3 08	19.7		751
3 58	12.4	971		4 11	10.2		521	4 07	10.4	1,270	
4 02	11.7		663	4 14	9.5	1,110		4 10	9.9		524
4 16	9.3		524	4 23	8.0	870		4 23	7.6		463
4 22	8.3	561		4 26	7.3		453	4 25	7.3	807	
				4 35	5.8	609		4 36	5.4	573	
				4 49	3.3	318		4 37	5.2		347
				4 53	2.6	242		4 49	3.1		279
5 05	0.6	90		5 00	1.3	170		4 58	1.5		172
								5 06	0.0		98
[4]5 08.5	0.0			[4]5 07.4	0.0			[4]5 06.2	0.0		
				[5]5 11	−0.6			[5]5 10	−0.7		
5 12	−0.6		37	5 15	−1.4		57	5 17	−2.0		27
5 20	−1.9		13	5 23	−2.9		14	5 29	−4.2		3
								5 38	−5.9		0.4

[1] Nov. 4. A few Fr. Cu. at noon. No clouds recorded during afternoon, but haze was dense, and sun disappeared in bank of haze.
[2] Nov. 5. No clouds. Brilliant sunset. Yellow sky with pink glow above, followed by dull red. Sky bright red on horizon at 6:19 p. m. Distinguishable at 6:28 p. m., but had disappeared at 6:32 p. m. (apparent time).
[3] Nov. 6. No clouds. Brilliant sunset; yellow, followed by pink and red.
[4] Computed time of sunset.
[5] Observed time of sunset.

Photometric measurements show that with a completely overcast sky the illumination on a hori ontal surface may be half as great as with a clear sky, and that not infrequently it is one-third as great. From the factor 6,250 derived above, in connection with the Callendar records of radiation on a horizontal surface, illumination intensities of only 168 foot-candles are obtained at noon in winter with a dense fog prevailing, and of only 85 foot-candles at noon in midsummer, during a severe thunderstorm.

In Table 5 are given photometric measurements on three afternoons in November, 1913, that were continued until after sunset. The computed time of sunset is for the center of the sun's disk and for the true horizon. The observed time is the time at which the upper limb of the sun actually disappeared behind distant hills that were somewhat below the horizon of Mount Weather. It will be noted that on November 5 and 6, both of which were days with clear skies and brilliant sunsets, the readings are in good accord. On the 4th, however, which was a hazy day, not only was the daylight illumination lower, but the twilight illumination also diminished much more rapidly with increased distance of the sun below the horizon.

With the discontinuance of solar radiation work at Mount Weather at the end of September, 1914, the Sharp-Millar photometer was sent to Salt Lake City, Utah, where daylight illumination measurements are being made under the smoke cloud, covering the center of the city, and also at a point in the suburbs that is comparatively free from smoke.

SUMMARY.

Photometric measurements made at Mount Weather, Va., show that with a clear sky the total midday illumination on a horizontal surface varied from 10,000 foot-

candles in June to 3,600 foot-candles in January. It is less than the direct solar illumination on a normal surface from September to February, inclusive, but exceeds the latter from May to August, inclusive, for a period of from four to eight hours in the middle of the day.

The illumination on a horizontal surface from a completely overcast sky may be half as great as the total illumination with a clear sky, and is frequently one-third as great. On the other hand, during severe thunderstorms at noon in midsummer, the illumination may be reduced to less than one per cent of the illunimation with a clear sky.

The ratio of sky-light illumination to total illumination on a horizontal surface at noon in midsummer varies from one-third to one-tenth. In midwinter it varies from one-half to one-fifth.

When the sky is clear the twilight illumination on a horizontal surface falls to 1 foot-candle about half an hour after sunset, or when the sun is about 6° below the horizon.

REFERENCES.

(1) **Sharp, Clayton H. & Millar, Preston S.** A new universal photometer. Electrician, 1908, **60**:562–565.

(2) *See* Bulletin of the Mount Weather Observatory, 1913, v. **6**, pt. 5, p. 218–219; and MONTHLY WEATHER REVIEW, March, June, and September, 1914, **42**:139, 310 and 520.

(3) MONTHLY WEATHER REVIEW, August, 1914, **42**:480.

(4) Annals of the Astrophysical Observatory of the Smithsonian Institution, Washington, 1913, **3**:135–138.

Smithsonian Physical Tables, 6th ed., 1914, p. 182.

HEAT FROM THE STARS.[1]

In the MONTHLY WEATHER REVIEW for June, 1914 (p. 347), were presented some figures expressing the amount of heating at the earth's surface which may properly be attributed to the radiation received from the planets of the solar system. Equally interesting is the similar question concerning the stars, those innumerable suns lying far beyond our own prime source of heat and energy. Among others Dr. W. W. Coblentz has attacked this problem, and first by constructing an exceedingly delicate radiometer. His instrument is essentially a bismuth–platinum, or a bismuth–bismuth plus tin alloy thermocouple exposed in a high vacuum. He has measured the radiation from 105 stars, among other celestial objects, and finds "that red stars emit from two to three times as much total radiation as blue stars of the same photometric magnitude."

Measurements were made on the transmission of the radiations from stars and planets through an absorption cell of water. By this means it was shown that, of the total radiation emitted, the blue stars have about two times as much radiation as the yellow stars, and about three times as much radiation as the red stars, in the spectral region to which the eye is sensitive. * * *

Measurements were made to determine the amount of stellar radiation falling upon 1 square centimeter of the earth's surface. It was found that the quantity is so small that it would require the radiations from Polaris falling upon 1 square centimeter to be absorbed and conserved continuously for a period of one million years in order to raise the temperature of 1 gram of water 1° C. If the total radiation from all the stars falling upon 1 square centimeter were thus collected and conserved it would require from 100 to 200 years to raise the temperature of 1 gram of water 1° C. In marked contrast with this value, the solar rays can produce the same effect in about one minute.

[1] **Coblentz, W. W.** A comparison of stellar radiometers and radiometric measurements on 110 stars. *Abstract in* Jour., Washington ac. sci., Washington, Jan. 19, 1915, **5**: 33–34. *Detailed paper will appear in the Bulletin of the U. S. Bureau of Standards.*

E. KRON ON THE EXTINCTION OF LIGHT IN THE TERRESTRIAL ATMOSPHERE IN THE REGION OF THE ULTRA-VIOLET.[1]

By WILHELM SCHMIDT.

Kron's report deals with photographic-photometric observations, by means of a quartz spectrograph, on the brightness (Helligkeit) of the sun at the Astrophysical Observatory at Potsdam, Germany, during the years 1911 to 1913. The extraordinary range [Abstufungsmöglichkeit] permitted by the conditions of the experiments enabled the region of accurate measurements to include both the extraordinary differences in intensity in the different spectral regions (between wave-lengths $430\mu\mu$ and $310\mu\mu$) and the total solar intensity as related to its altitude above the horizon (measurements being possible down close to it). There is nothing new in the methods of computation which are based upon the Bouguer Formula and Bemporad's values for the air masses.

In general it appears that the coefficient of transmission p is subject to variations from day to day, while the observations for the same day show good agreement among themselves with departures due to increased absorption for the lowest solar altitudes as would be expected if masses of vapor occur. The mean values obtained by Kron are in part essentially lower than those secured in 1909 and 1910 by C. G. Abbot[2] on Mount Whitney; as the following comparison shows. The third column of values have been reduced to Potsdam barometric conditions by multiplying.

Values for the coefficient of atmospheric transmission, p, *by Kron (Potsdam) and Abbot (reduced to Potsdam).*

Wave length. λ	Kron's value for p.	Abbot's value for p (reduced).
μ 0.432	0.648	0.762
.390	.531	.678
.371	.464	.629
.341	.354	.531
.325	.268	.457

Since only the last of the Abbot values seems to have been increased by the action of diffused light in his instrument, it is at least evident that values determined for a high-level station can by no means be directly reduced to low-lying stations.

Rayleigh is the authority for the assumption that it is particularly the absorption in the region of the shortest wave-lengths (except certain bands, e. g. those due to ozone, below 0.325μ), which is produced by scattering from air molecules so that its amount is inversely proportional to the fourth power of the wave-length, λ. If one computes from Kron's observations the absorption-coefficients $C = \log \text{nat } p$, then they may be readily represented by a formula of the form

$$C = \frac{\alpha}{\lambda^4} + \beta,$$

where $\alpha = 0.01325$ and $\beta = 0.066$. The small value of β at once shows the formula closely in agreement with the above law, while this agreement is yet further improved

[1] A translation of a review in Met. Ztschr., Braunschweig, November, 1914, **31**: 555–6.—C. A. jr.

[2] Annals of the Astrophysical Observatory of the Smithsonian Institution, vol. 3, Washington, 1914.